Renewable and Sustainable Energy Reviews 15 (2011) 1169–1181

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Promotion of renewable energies in Algeria: Strategies and perspectives

Amine Boudghene Stambouli *

Department of Electronics, Electrical and Electronics Engineering Faculty, University of Sciences and Technology of Oran, BP 1505, EL M'Naouer, Oran 31000, Algeria

A R T I C L E   I N F O

Article history:
Received 14 September 2010
Accepted 9 November 2010

Keywords:
Solar
Wind
Hydro
Biomass and geothermal

A B S T R A C T

During the last few years, political support for renewable energies has been growing continuously both at the national and international level and most scientists now agree that the Middle East and North Africa (MENA) are perfectly placed to play a leading role in the lucrative future solar and wind power industries. The interest for the development of renewable energies was perceived very early in Algeria with the creation of the solar energy institute as soon as 1962. Algeria plays a very important role in world energy markets, both as a significant hydrocarbons producer and exporter, as well as a key participant in the renewable energy market. Due to its geographical location, Algeria holds one of the highest solar reservoirs in the world. This paper deals with a review of the present renewable energy (RE) situation and assessed present and future potential of RE sources in Algeria. It also discusses the trends and expectation in solar and wind systems applications and the aspects of future implementation of renewable energies making emphasis on the Middle East and North Africa (MENA) region status. The problem related to the use of RES and polices to enhance the use of these sources are also analysed in this paper. In addition the available capacity building, the technical know-how for each RE sources technology and localising manufacturing of RE equipments have been defined.

Contents

* Tel.: +213 41 56 03 29; fax: +213 41 56 03 01.
E-mail addresses: aboudghenes@yahoo.com, boudghene@univ-usto.dz

1364-0321/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2010.11.017

1. Introduction

The quality of life and safeness of the present and future generations are strongly intertwined with the availability of energy sources and the sustainability of the energy infrastructure. Energy consumption in developed countries grows at a rate of approximately 1% per year, and that of developing countries, 5% per year [1,2]. Present reserves of oil and natural gas can only cover consumption at this rate for the next 50 years in the case of oil, and for the next 70 in the case of natural gas. Therefore, one of the fundamental priorities for a country such as Algeria is to use several RE sources and environmentally friendly energy conversion technologies.

The important economical changes undertaken these last years on the national and the international levels, led Algeria to embark on structural reforms. These reforms aim to a progressive adaptation, notably in the Energy sector (fossil and renewable energies), so as it will be comply with a free, open and competitive economy. In this perspective, the Algerian state intends to promote and speed up a greater and more diversified participation of the Energy private sector for investments development, technologies acquisitions, know-how and access to foreign markets. This new policy required changes of the legal and institutional frameworks that the government has pursued, on both the global and sector-based levels.

The interest for the development of renewable energies was perceived very early in Algeria with the creation of the solar energy institute as soon as 1962. This willingness to promote renewable energies notably resulted in: the setting of specialised agencies to promote research and development in this field, the development of sensitivity and popularisation actions for the purpose of these energy sources promotion, the setting of an institutional environment necessary to give impetus to real renewable energies development programs and the creation of small and medium services companies specialised in the installation and maintenance of equipment, engineering, surveys and consulting. Considering the stakes represented by these long-lasting energy sources, the authorities have established the prevailing and strategic feature of renewable energies through the institutional frame recently defined.

In July 2002, Sonatrach (National Company of Hydrocarbons, Research, Production, Transport, Transformation and Marketing, 45%), Sonelgaz (Algerian Company of Electricity and Gas, 45%) and the private company SIM (10%) formed a joint venture, New Energy Algeria (NEAL) [3], to pursue the development of alternative electricity sources including solar, wind and biomass. New Energy Algeria (NEAL) to pursue the development of alternative electricity sources has joined the International Energy Agency's SolarPACES programme and incorporated renewable energy targets into national laws to help create a stable environment for long-term investors. Having ambitious quantitative targets, the Algerian's environmental friendly energy strategy has set up solar and wind projects generating 575 MW by 2015, 1400 MW by 2020 and 7500 MW around 2030, though the trends are positive. In addition, Algerian Ministry of Energy and Mines as well as investors can choose to link up with a certain manufacturer for each renewable energy technology (RET), such as Japan, German and Spanish in a variety of joint ventures. This coupling can include significant technology transfer to local companies and therefore build and develop local manufacturing.

One of the renewable energies development objectives in Algeria made by the Ministry of Energy and Mines (MEM) is to supply the isolated zones, far from the gas distribution networks (electricity and oil products), with energy services. Another objective is to contribute to the preservation of hydrocarbons reserves by the exploitation of the renewable energies resources field, solar, in particular. The large exploitation of the solar field with the aim of producing electricity connected to the framework will contribute to the satisfaction of the national needs and will, in terms, find an outlet to the export towards European countries. This prospect fits with the long-lasting development process with the contribution to the preservation of environment. Programmes have included different solar applications: rural electrification, photovoltaic pumping, water heating and other industrial applications (Algeria's commitment to its National Rural Electrification Programme, which continues to provide solar power to villages in southern Algeria, following a successful first phase, the second phase is now underway).

In keeping with natural gas valorisation policy, an electricity export project towards Europe from a power station of 2000 MW is being implemented in the frame of an international partnership. Another objective of Algeria is to contribute to the preservation of hydrocarbons reserves by the exploitation of the renewable energies resources field, solar, in particular. The large exploitation of the solar field with the aim of producing electricity connected to the framework will contribute to the satisfaction of the national needs and will, in terms, find an outlet to the export towards European countries (6000 MW in 2020) [5].

The setting up of a specific and competitive energy tax system (for renewables), combined to the formulation of more inciting investment conditions, will give a new impulse to the energy sector activities development.

The law on Electricity No. 02-01, enacted on 5th of February 2002, devotes the liberalisation of the Electricity sector with the opening of electricity production and distribution to competition and the non-discriminatory access of a third part to the network, while reaffirming public service maintenance. The bill on hydrocarbons aims to developing sources of incomes, by improving the quantity and quality of products and energy services supplied to consumers and by developing the loyal competition in an open and non-discriminatory framework.

2. Geographic location of Algeria

Algeria's geographic location has several advantages for extensive use of most of the RES (solar and wind). Algeria situated in the centre of North Africa between the 38–35° of latitude north and 8–12° longitude east, has an area of 2,381,741 km^2 and a population of 32.5 millions of inhabitants (13.7 inhabitant/km^2) [4].

Administratively speaking, Algeria is divided into 48 provinces and lies, in the north, on the coast of the Mediterranean Sea. The length of the coastline is 2400 km. In the west Algeria borders with

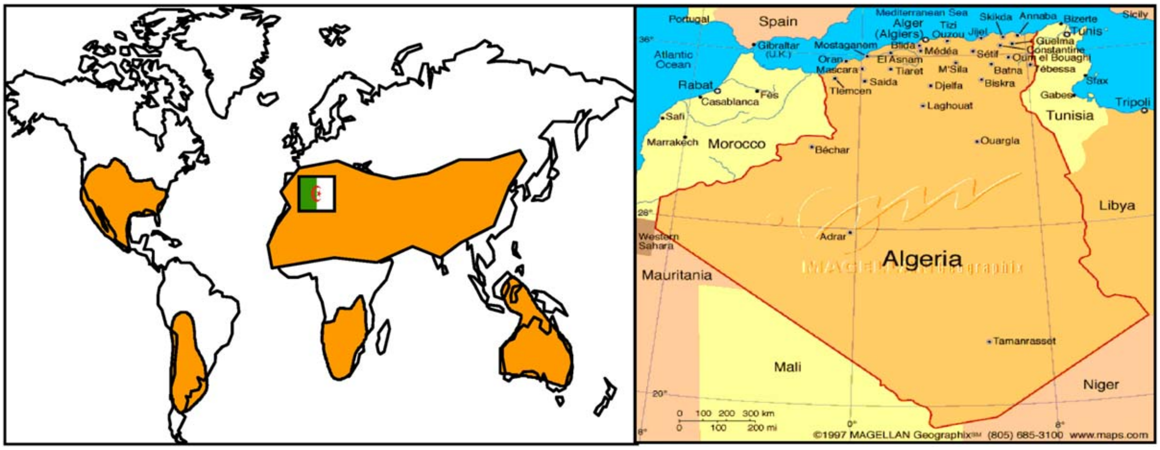


Fig. 1. Solar suitable sites in the world and the Map of Algeria situated in the solar belt of the middle of the world.

Morocco, Mauritania and occidental Sahara, in the southwest with Mali, in the east with Tunisia and Libya, and in the southeast with Niger (Fig. 1).

The climate is transitional between maritime (north) and semi-arid to arid (middle and south). The mean annual precipitation varies from 500 mm (in the north) to 150 mm (in the south). The average annual temperature is around 12 °C.

Three Ss should be the national energy policy drivers of Algeria namely: Solar, Sand and Space. The Sahara (south of Algeria) covers a total area of 2,048,297 km^2, approximately 86% of the total area of the whole country.

The geographic location of Algeria signifies that it is in a key position to play an important strategic role in the implementation of renewable energy technology in the north of Africa, as well as providing sufficient energy for its own needs and even exporting such projects to other countries of Europe. A report by the International Energy Agency's (IEA) programme says country such as Algeria could one day be exporting solar energy to markets in Europe, as it will soon be connected to European energy networks. The report says also that in 20 years, solar power could provide the same amount of electricity as 72 coal-fired power stations. This is enough to supply 100 million people, or the combined populations of Algeria, Morocco, Tunisia and Libya.

3. Energy data for Algeria

Algeria plays a central role in the energy world, as it is a major producer and exporter of oil and natural gas. In 2008, Algeria produced approximately 1.4 million barrels per day (mbbl/d) of crude oil, of which 85% was exported, and 86.5 billion cubic meters (bcm) of natural gas, of which 70% was exported, mostly to Europe. Algeria was the fourth largest crude producer in Africa, and the sixth largest natural gas producer in the world. Oil and gas export revenues account for more than 95% of Algeria's total export revenues, around 70% of total fiscal revenues, and 40% of gross domestic product (GDP). Compared to other developing countries with a similar GDP, Algeria's energy consumption is high: 1.2 tons of oil equivalent (TOE) and 840 kWh of electricity per capita. However, these figures include selfconsumption and losses in the energy sector due to LNG exports. The share of oil in the country's overall consumption fell from 40% in 1990 to 34% in 2007; the share of gas increased from 57% to 64%. In industry, gas accounts for nearly 53% of final consumption. Gas consumption also increased substantially in the residential sector, and in 2007 accounted for 46% of final energy consumption. This evolution shows the progressive adequacy of

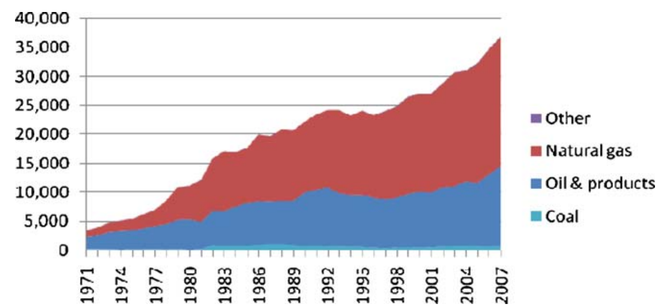


Fig. 2. Algeria total Primary supply in kTOE (IEA source).

offer structure to the structure of our present reserves, richer in natural gas [5,6] (Fig. 2).

Algeria's revenues come mainly from exporting fossil fuels. In spite of a clear progression of national consumption, exportations' share in energy commercial production remains determining (80%). It has passed from 56 MTOE in 1980 to 133 MTOE in 2003 and 142 MTOE in 2005.

Reserves of oil announced in Algeria are 4.5 billion of TOE. Estimates of natural gas reserves, in 2004, were around 4.52×10^{12} m^3, which implies a lifetime of 62.2 years compared with an expected 61.9 years globally [7].

The national energy commercial consumption passed from 6 MTOE in 1970 to 32.7 MTOE in 2002, over 35.2 MTOE in 2003 and just under 40 MTOE in 2005. In unit terms, national consumption passed from 0.3 TOE/inhabitant in 1970 to 1 TOE/inhabitant in 2003 that is a tripling of the unit consumption in 30 years. The production of electricity in Algeria was 25.8 billion kWh in 2002 and 40.06 billion kWh in 2007 and the country consumption is between 25 and 30 TWh/year [8].

As Algeria population grow many faster than the average 3%, the need for more and more energy is exacerbated. In Algeria, the consumption of energy at the national level is increasing year after year due to demographic and urban development, in addition to economic development in constant progression. As far as the resources are concerned, based essentially on oil and natural gas, they are not unlimited and are slowly being exhausted.

Algeria generated, over the last 5 years, 185.8×10^9 kWh of electricity. Conventional thermal sources of which natural gas accounted for 94.5%, contributed almost all of Algeria's electricity, supplemented by a small amount of hydroelectricity (5%) and solar photovoltaic/wind (0.5%) [6,9]. Algeria is now positively disposed to the promotion of RES and views renewables as a way of pro-

moting the development of small and local businesses in selected areas and diversifying supply patterns at the regional level. Algeria has developed national programmes and set national indicative targets for renewables: to pursue the development of alternative electricity sources, including solar and wind to achieve a share of renewable energy sources in primary energy supply of 5% by 2017 and 10% by 2020.

In a context of economic recovery, energy demand could double by the year 2020 (60 MTOE, even 70 MTOE) by increasing uses of energy and economic activities.

The country is connected to Europe through two gas pipelines, to Italy via Tunisia, and to Spain via Morocco. Three additional pipelines are in development: Medgaz, linking directly Algeria to Spain, Galsi, from Algeria to Sardinia and the Italian mainland, and Trans-Saharan, from Nigeria to Algeria. This pipeline would make it possible for Nigeria to export part of its production tEurope through Algeria. With it, Algeria would not only be an energy hub between North Africa and Europe, but also between the whole African continent and Europe. Algeria also has four liquefied natural gas (LNG) plants, with a fifth one in development (LNG accounts for one third of Algeria's gas exports). The hydrocarbon sector is dominated by state-owned Sonatrach, whose objective is to increase the gas export capacity form the current 65 bcm per year, to 85 bcm per year around 2010–2012, and 100 bcm per year by 2015 [10].

3.1. Renewable energies potentials

The size of the Algerian Sahara could capture enough solar energy to meet the entire world's electricity needs, according to Mr. Kaveh Zahedi, Deputy Director, UNEP's World Conservation Monitoring Centre, based in Cambridge [8].

The assessed potentials (economic), by the German Space Centre (DLR), of renewable energy sources in Algeria are [11]:

- Thermal solar (TS): 169,440 TWh/year
- Photovoltaic (PV): 13.9 TWh/year
- Wind energy (WE): 35 TWh/year

Algeria is in urgent need of an adequate energy infrastructure so that it can achieve higher levels of economic development. This would allow all of its inhabitant's access to a quality energy supply, irrespective of their place of residence. Crucial objectives are targeted at substantially increasing and enhancing the contribution of renewable energies and favouring energy self-sufficiency.

Pilot projects implemented in recent years justify the possibility to accelerate the use of indigenous energy resources, particularly for electricity supply.

Table 1
Solar potential in Algeria.

Areas	Coastal area	High plateau	Sahara
Surface (%)	4	10	86
Average duration of sunning (h/year)	2650	3000	3500
Received average energy (kWh/m^2/year)	1700	1900	2650

The solar deposit exceeds the 5 billion GWh.

The Government of Algeria has introduced a national program for integration of renewables with an objective to reach 5% of power generation by 2017 and a long-term target of achieving 20% renewable energy power by 2030. Further, the long-term goal is to be met primarily from the Concentrated Solar Power (CSP) (70% CSP, 20% wind and 10% PV) which would make it among the world's most ambitious CSP programs. Through a March 2004 decree, the Government also introduced incentives for electricity production from renewable energy plants, including a feed-in tariff [12].

4. Solar energy

The history of using solar energy in Algeria backs to 1954 with the solar furnace built by the French for ceramic fabrication purpose. The insulation time over the quasi-totality of the national territory exceeds 2000 h annually and may reach 3900 h (high plains and Sahara). The daily obtained energy on a horizontal surface of 1 m^2 is of 5 kWh over the major part of the national territory, or about 1700 kWh/m^2/year for the North and 2263 kWh/m^2/year for the South of the country (Table 1 and Fig. 3) [13].

The development of solar energy plants is supported by the MEM and realised mainly by Sonelgaz and other private installers companies. The solar energy is regarded as an important line of research within the structure of the department of renewable energies of Sonelgaz.

4.1. Rural electrification by photovoltaics solar energy

It relates to the electrification of eighteen (18) villages very far away from the networks existing and located primarily in the provinces of the great south (Adrar, Illizi, Tindouf and Tamanrasset). This program is financed entirely by the Special Funds for Development of the South Areas from the Ministry of Energy and Mines.

Sonelgaz have gone down the solar route for these 18 villages in the rural electrification programme with the aim of kick-starting the use of renewable and particularly photovoltaic energy (list of villages in Table 2) [14].

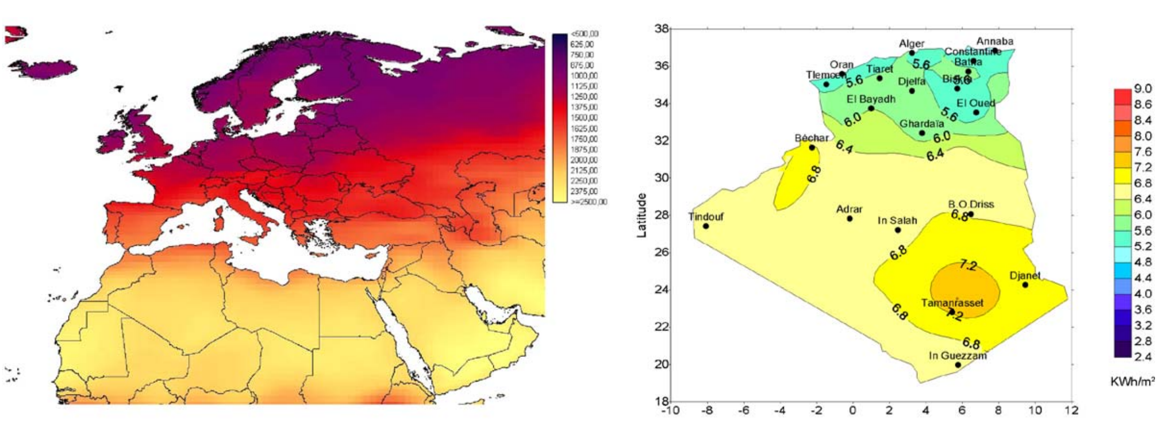


Fig. 3. Potential sites for solar electricity supply from North Africa (in kWh/m^2/year) and example of the overall daily exposure received (in kWh/m^2/day) in Algeria.

Table 2
Installed power and daily home consumption (a), global installed power (b) and distribution per province of the PV installations (c).

Province	Village	Installed power (kW)	Consumption (kWh/day/home)
(a)			
Tamanrasset	Moulay lahcen	9	1.48
	In delagh	15	0.92
	Tahifet	61.5	1.30
	Arak	61.5	1
	Amguid	51	1.60
	Tahernenet	30	1.13
	Tin tarabin	34.5	1.44
	In blel	15	1.38
Tindouf	Gara djebilet	33	1.47
	Daya el khadra	24	1.55
	Hassi mounir	21	1.68
Adrar	Hamou moussa	6	1.53
	Tala	16.5	1.61
Illizi	Imehrou	16.5	0.63
	Ifni	7.5	0.60
	Oued samen	15	0.68
	Tihahiout	12	0.57
	Tamadjart	24	0.80

	System (kWp)			Total
(b)				
Power type	1.5	3	6	
Number of installed systems	10	50	48	108
Connection capacity in number of homes	30	300	576	906
Global installed power	453 kWp			

Province	Homes by unit	Power in (kWp)	Energy (kWh)	Stock (kWh)
(c)				
Tamanrasset	555	277.5	1665	4026
Illizi	150	75	450	1100
Tindouf	156	78	468	1144
Adrar	45	22.5	135	330
Total	906	453	2718	6600

The solar applications, by implanting photovoltaic power plants, are an extension of already existing diesel power stations in isolated areas and are limited to electrification, pumping, telecommunication, public lighting and small refrigeration systems. The photovoltaic installations used are of the semi-collective type.

The concerned 18 villages which have benefited from these installations have been selected according to their geographical location. These villages, situated in the South, with a small number of households, were typified by their isolation and their remoteness from any communications network. Supplying them by conventional methods (diesel, transmission grid), in addition to excessive start-up costs, would have posed the problem of trucking in the fuel, and in the case of the grid, of undoubted difficulties in constructing and maintaining the overhead lines.

One of the strengths of photovoltaics is to be found in its decentralised applications, cutting out the cost of transporting the energy produced. This is particularly true for supplying isolated consumers in areas of low population density, where the demand consists essentially in satisfying basic energy requirements (light, refrigeration, pumps, television and radio). Other notable characteristics of photovoltaics are:

- Modular design enabling it to be extended according to need.
- The possibility of developing small businesses in areas of low economic development.
- Protection of the environment.
- Limited capital assets, capable of being used flexibly and in a decentralised way, and of being moved about over longer periods of time.

Table 3
List of new CSP proposed generation projects in the Algerian investment plan.

Location	Capacity (MW)	Est. cost (10^6 US$)
Megahir	80	322
Naama	70	285
Hassi R'mel II	70	285

This developing strategy, by Sonelgaz, has been elaborated to promote the dissemination of renewable energies on sites where they are profitable compared to classical energies and to guide scientific research efforts in order to allow generalisation of renewable energy via mass production. The aims to be achieved consist of the contribution to a conservative policy for hydrocarbons both by increasing the renewable energy share within the national energy balance and by improving the living conditions of isolated communities. In the absence of any reference, this first operation led by Sonelgaz would allow on one hand to supply isolated area with electricity and on the other hand to collect information about:

- Equipment behaviour in Saharan environment
- Matching the systems with the electricity supply
- Maintenance organisation and management
- Technical-economic system optimisation

The rural electrification second phase project will be approached with the same way as certain similar projects developed in the neighbouring countries. The role of NEAL would be in this case a provision of a financial engineering service. It is a question, for the populations non-connected to the network, of being able to profit from photovoltaic systems of production of electricity for the domestic needs and the pumping of water. The law on electricity offers the possibility to build the development of the production of electricity by concessions, which can be connected to private companies created around villages in the South for the benefit of local entrepreneurs. The society of capital development (capital risk) being a privileged tool of financing in this case.

4.2. Concentrated Solar Power (CSP) in Algeria

Many parts of the world are physically suitable for CSP development including the whole of the MENA region. Of these areas Algerian's Sahara is particularly attractive for early market development given the land availability and proximity to large high paying markets. The potential for power generation is enormous compared to regional and global energy demands-roughly 2% of the Sahara desert could meet the world demand and 0.4% could meet Europe (EU) demand (DLR, 2005; Gelil, 2007; ESTELA, 2009).

The long-term target of achieving 20% renewable energy power by 2030 is to be met primarily from the CSP (70% CSP, 20% wind and 10% PV) which would make it among the world's most ambitious CSP programs. In order to meet these ambitious targets, NEAL is implementing solar projects such as the first 25 MW solar power project at Hassi R'mel (150 MW in total, CSP/natural gas) which is under implementation and three new projects under various stages of consideration as seen in Table 3 [10].

Looking to the future, a proposal named DESERTEC was put forth by the Trans-Mediterranean Renewable Energy Cooperation (TREC). The solar plan envisages a network linking North Africa and Europe that will tap the vast solar and wind resources of North Africa to bring clean energy to Africa and Europe. Based on the DESERTEC concept a consortium of 12 large companies of the energy, technology and finance sector (including Munich Re, Siemens, Cevital, Deutsche Bank, RWE, EON, Schott Solar) formed a DESERTEC Industrial Initiative (DII) in October 2009 that will con-

Table 4
The annual average wind velocities in the six identified places.

Sites	Adrar	Tindouf	Bordj Badji Mokhtar	Bechar	Tamanrassat	Djanet
Annual average speed (m/s)	6.3	5.1	4.6	4.4	3.7	3.3

duct feasibility studies and develop project plans to realise a large solar electricity export from the MENA to Europe [10]. On their first meeting in July 2009 in Munich the consortium emphasized their intention to invest € 400 billion over the next 40 years to supply 15% of the European electricity market by imported solar electricity produced in North African CSP plants. In the first phase, DII will focus on advocacy for opening the EU market to MENA CSP exports. In the medium term, the program will provide the necessary industry and government experience, and market development to enable the large scale private sector investments envisaged by DII members.

5. Wind energy

Wind energy can be feasible where the average wind velocity is higher than 5–6 m/s. Algeria has a huge plan to develop wind energy. Studies of indigenous wind resources in Algeria performed by the Renewable Energy Development Centre (CDER) during recent years show that the climatic conditions in Algeria are favourable for wind energy utilisation.

The wind map established by the MEM shows that 50% of the country surface presents a considerable average speed of the wind. The best wind energy potential is in the South especially in the South-Western region where the wind velocity is higher than 6 m/s as seen in Table 4 showing the annual average wind velocities and power in the three sites of the South-West region of Algeria. This energy potential is ideal for the water pumping especially in the high plains.

The wind resource has also been assessed by the developer, Sonelgaz, and at present, there are six pilot projects for electrification and telecommunication which are identified and quantified. These are Adrar, Tindouf, bordj Badji Mokhtar, Bechar, Tamanrassat and Djanet. The annual average wind velocities in these six places are shown in Fig. 4 and Table 4 [15]. The region of Adrar receives the most wind in the country judging from the results of the preliminary survey. Evaluations of powers recoverable at heights from 10 to 50 m could conclude in registering this region as a favourable site for the establishment of a windy farm. Other sites (North, High Plateaux) hide non-negligible energetic potentials (usable energy, Fig. 3). The installation, by Sonelgaz, of nine assessment stations in different regions of Algeria is seen as a second step in stimulating much faster the use of the wind power. Fig. 3 also presents the nine stations throughout Algeria [sonelgaz]. The topography and terrain roughness of these prospective wind sites are also measured and quantified to better simulate and understand the wind flow [15].

6. Photovoltaic and wind installations throughout Algeria

The distribution per province of the photovoltaic and wind installations, the distribution of installed power per applications and the distribution of installed power per resources are respectively listed in Tables 5–7 [6]. The overall installed power is 2.353 MW.

7. Hydroelectricity potential

The overall flows falling over the Algerian territory are important and estimated to 65 billion cubic meters but of little benefit to the country: restrained rainfall days, concentration on limited areas, high evaporation and quick evacuation to the sea.

Schematically, the surface resources decrease from the North to the South. Currently the evaluation of useful and renewable energies is about 25 billion cubic meters, of which the 2/3 approximately is for the surface resources.

103 dam sites have been recorded. More than 50 dams are currently operational. The share of these small-sized production parks is about 5% which supplements the natural gas production of electricity [16]. The total capacity of 13 of them is 269.208 MW as shown in Table 8.

Hydraulic electricity represented, with 265 GWh in 2003, barely 1% of the total electricity production.

8. Geothermic energy

Concerning the geothermic energy hot springs are numerous but not exploited for industrial ends. More than 200 geothermal sources were counted by the Centre of renewable energies development (CDER) [13] and are recorded of which one third's temperatures are superior to 45 °C and where the highest temperatures registered are 98 °C and 118 °C in Hamam El Maskhoutin and Biskra, respectively, situated in the western part of the country. Geothermic is not to be excluded from the electric option of the renewable energies network. Some of these sources can be exploited for the purpose of renewable electricity production.

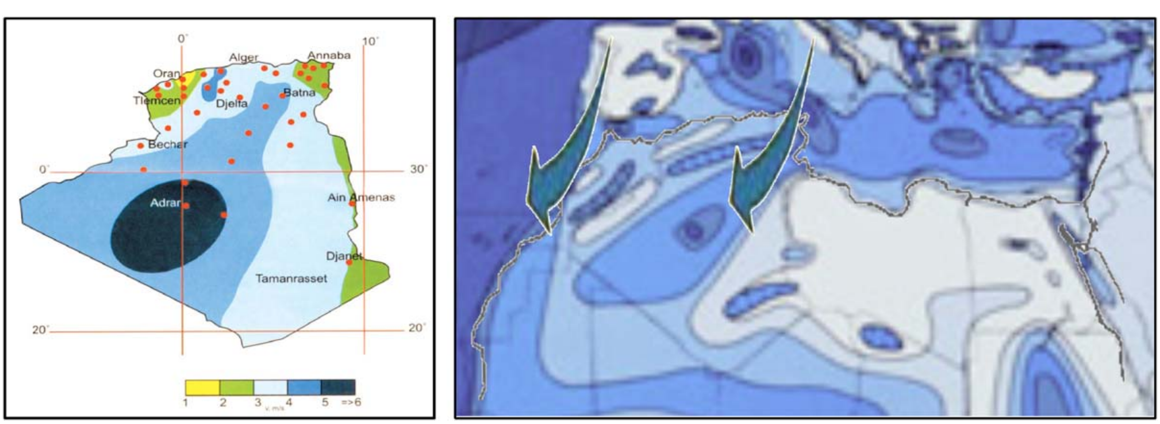


Fig. 4. Fig. 3: Wind chart of Algeria.

Table 5
Distribution per province of the photovoltaic/wind installations.

Provinces	Resource	Installed power (W)	Provinces	Resource	Installed power (W)
Algiers	Solar/Wind	46 610	Medea	Solar	5000
Adrar	Solar	234,900	M'sila	Solar/Wind	45,500
Batna	Solar	7500	Naama	Solar/Wind	88,400
Bechar	Solar	48,000	Ouargla	Solar	60,600
Biskra	Solar	5000	Oum El Bouaghi	Solar	12,500
Blida	Solar	6000	Saida	Solar	40,200
Bordj Bou Areridj	Solar	2000	Setif	Solar	4800
Bouira	Solar	3000	Sidi Bel Abbes	Solar	39,000
Constantine	Solar	1500	Souk Ahras	Solar	6000
Djelfa	Solar/Wind	114,700	Tamanrassat	Solar	578,500
El-Bayad	Solar	78,500	Tebessa	Solar	64,000
El-oued	Solar/Wind	31,000	Tiaret	Solar/Wind	89,500
Ghardaia	Solar	32,750	Tindouf	Solar	96,150
Illizi	Solar	153,850	Tipaza	Solar	2400
Khenchla	Solar	13,000	Tizi Ouzou	Solar	6000
Laghouat	Solar/Wind	93,300	Tlemcen	Solar/Wind	54,500
Mascara	Solar	1000	Other realisations	Solar	287,600
Total solar/Wind: 2,353,260					

Table 6
Distribution of installed power per applications.

Applications	Installed power (W)	Percentage %
Electrification	1,352,800	57
Pumping	288,400	13
Public lighting	48,430	2
Telecommunication	498,000	21
Others	165,630	7
Total	2,353,260	100

Table 7
Distribution of installed power per resources.

Resources	Installed power (W)	Percentage
Solar	2,279,960	97
Wind	73,300	3
Total	2,353,260	100

9. Biomass energy

The biomass potentially offers great promises with bearing of 3.7 MTOE coming from forests and 1.33 MTOE per year coming from agricultural and urban wastes (365 kg per Algerian as urban wastes); however this potential is not enhanced and consumed yet.

A pre-survey showed the feasibility of production of electricity by modals of 2 MW that can reach a peak of 6 MW from the discharge of Oued Smar in Algiers. The study integrates the drainage of the site [17].

10. Algerian market of renewable energies

The market of renewable energies is very small. There is a market of electricity, which, at present time, is largely defined by the law 02-01 on electricity and distribution of gas. A statutory text or the decree on the costs of diversification aims at bringing the share of electricity produced by the renewable energies to 5% of the total electricity to be produced by 2015, by introducing incentive measures for all the branches of energies used to produce electricity.

The promotion of solar energy is undergoing spectacular acceleration with, particularly, the launch of the important hybrid solar-gas power plant in Hassi R'mel, among many others that are eligible for the clean development mechanism's financing.

Table 8
Hydroelectric production park.

Plant	Installed power (MW)	Plant	Installed power (MW)
Darguina	71.5	Ighzernchebel	2.712
Ighil Emda	24	Gouriet	6.425
Mansouria	100	Bouhanifia	5.700
Erraguene	16	Oued Fodda	15.600
Souk El Djemaa	8.085	Beni Behde	3.500
Tizi Meden	4.458	Tessala	4.228
Ghrib	7.000	Total	269.208

10.1. Share of the renewable energies in the market of energy

The joint-stock company NEAL, created on 28th July 2002, is the first public-private partnership. Its registered capital of 200 million Algerian Dinars (DA) is shared among Sonatrach 45%, Sonelgaz 45% and SIM 10%. NEAL is a company developing projects in the production of electricity and heat from the renewable energies, which are the thermal solar, the photovoltaic solar, the wind, the geothermic and the biomass. It has also the dimension of promotion of GPL (Bupro) to fight against deforestation of the south of the country.

The percentage of renewable energies in our national energy balance remains insignificant (18 PV electrified villages in the south and telecommunication relay). But this situation cannot stay in an embryonic stage and the interest of introducing renewable energies in Algeria is becoming a declared desire of the public authorities; the results of the proposed actions will enable assessment and decision making elements to be given to the energy policy players.

The action plans of the years 2004–2005 particularly has planed to make a clear diagnosis of the evaluation subsidiaries of this type of energy, to make the public authorities and the industrial players aware of this and to propose a national renewable energy development strategy (a long-term target of achieving 20% renewable energy power by 2030). A first Integrated Solar and Combined Cycle (ISCC) plant is currently under construction at Hassi R'mel (152 ha, hybrid parabolic trough/gas-fired combined cycle, capacity: 25 MW CSP, 150 MW in total, Euro 315 million). This project will give Algeria valuable experience in the development, construction and operation of an ISCC.

10.2. Targeted share of the renewable energies market

The setting up of a portfolio of projects will be based fundamentally upon an approach to the market. The local market will be stated now as the statutory texts and will be enforced such as the decree on the costs of diversification.

The last meeting on energy, held in Roma between the Ministers of the European Union and the Maghreban countries (Morocco, Algeria, Tunisia and Libya), retained in its declaration the promotion of the production of electricity derived from renewable energies in the Maghreb region. The following objectives have been selected [18]:

- For the local market, the size should reach 500 MW by 2015.
- For exportation, the objective of the forthcoming 5 years remains the European market, which is able to absorb 1000 MW by 2015 in renewable energy coming from Algeria.

11. Social and ecological impact of renewable energy projects

The promotion of the renewable energies was thought with the objective to reinforce and favour the emergence of a local industry or a partnership in order to take a position in this market. In other word, the approach chosen by the sector of energy is based on the reform introduced by the law 02-01 of electricity and distribution of gas, which permitted, by exploiting the forces of the market, to promote the renewable energies in a long-lasting way. The portfolio of NEAL represents:

- A project of 400 MW solar-gas hybrid (2015).
- Wind project of 10 MW planned in the south-west of the country namely Adrar, operational by 2012.

Projects in maturation:

- Rural electrification (second phase after the 18 villages)
- Biomass
- Manufacturing of solar water heater
- Marketing Bupro (avoiding deforestation)

The prospects remain up to the size of the market of energy. The country could make shift its exports outside hydrocarbons in a significant way within the forthcoming 15 years by becoming the major energetic Hub of Europe in fossil and renewable energies. This strategy should rest on the policy of mastery of the know-how in the most determining technological branches. They selected the solar concentrators and engaged the plan of action for this purpose. The engineering main centre is in the course of creation. This technological branch was chosen by the five biggest projects actually in realisation or in project throughout the world, in addition to the 350 MW in operation since 1980 in United States. The share of the national goods and services is estimated at 32% out of the total. An industry of assembling of the solar fields in need of manpower would permit to stimulate a local development. Moreover, 1000 MW of solar concentrators would avoid the emission of 2300 kg of CO_2. In other respect, also for 1000 MW of solar concentrators, we'll have [6]:

- 500–1000 jobs created in the exploitation
- 5000–10,000 jobs in the construction
- 2000–4000 jobs in the manufacturing
- 400,000 tons of iron
- 500,000 tons of concrete
- 110,000 tons of glass

This project would be localised in the Souf (south-east of Algeria). It is also planned, within the framework of this project, to integrate a unit of desalination of briny water (currently 5 m^3/s of slightly salted water are rejected in the Chott) that would permit to irrigate 5000 ha. It will also permit to solve the serious problem of treatment of waters that polluted the environment and caused the destruction of 1000 palm trees. This project should be initiated in the course of this year on the same modal as the other projects of production of electricity, by calling on the private investors.

The Ministry of Energy and Mines, coordinating the procedure of tender and the statutory purview permits to find all the reassurances of the project from the market until the incentive measures likely to satisfy the investors and the financiers.

11.1. Manufacturing of solar water heaters

Algeria remains the single Mediterranean country where solar production is very low. A programme initiated by APRUE (National Agency for the Promotion and Rationalization of the use of Energy) would permit to determine the best approach to the penetration of the solar water heaters. It is also a project included in the ministry portfolio.

12. Legislative and statutory framework

The major text of the legislative purview concerning the electricity production from renewable sources is the law 02-01 dated on the 5th February 2002 relative to the electricity and distribution of gas through pipelines. This law fixed the legislative framework of the electricity production in application of the reforms of the Algerian electric system. These provisions apply to all the branches of production, including thus the branches of production of electricity from renewable sources, at least what concerns the provisions of a general nature. However, for the reasons mentioned in the previous article, the legislator provided particular clauses in order to make up the handicap of competitiveness of the renewable electricity by instituting the mode of support judged to be the most consistent with the Algerian context, and which is in coherence with the principle of competitiveness stated in the introductive article of the title III of electricity production, article 6 of the law. The mode of support selected is the call for tenders. This system of support is clearly announced in article 26 of the law stipulating it. In application of the energetic policy, the Commission of regulation can take measures of organisation of the market with a view to insure the normal disposal on the market at a minimal price of a minimal volume of electricity produced from renewable energies sources or of cogeneration system. The extra costs resulting from these measures can be subject to an endowment by the State and/or be taken into account by the fund of electricity and gas and charged to the tariffs. The quantities of energy to sell on the market and targeting the encouragement of the renewable energies or of cogeneration should be subject to a call for tenders defined through statutory channels. This quantity of electricity produced from renewable sources benefits thus from a special system. This special system is clarified in the Draft executive decree relative to the costs of diversification of the electricity production that was adopted by the Council of government of 28th January 2004. It should be remarked that according to the terms of article 26, the electricity production produced by the systems of cogeneration benefits from the same status as the renewable electricity. The notion of costs of diversification is introduced by article 95 of the law. The costs of diversification are the additional costs inherent to a technological choice to use the renewable energies. The producers can be paid premiums in compensation of these costs. This denomination of costs of diversification is the expression of an important option of the Algerian energetic policy: the need to diversify the primary sources of energy.

The recourse to the renewable sources, since it is about a deliberate choice of a branch for national interest reason, justifies the compensation granted to the producers. In accordance with the

law (art. 98), the costs of diversification are integrated in the tariffs. The user and the final consumer participate in the financing of this option. The eligible customers, that is to say the customers that are not liable to the system of tariffs and who can conclude freely contracts of supply of electricity with producers, will also participate in the cover of the costs of diversification (art. 103 of the law). The choice for the call for tenders is considered as a system of support to the renewable energies. The system of the call for tenders as a system of support to the production of renewable electricity is particularly well adapted, as recalled above, to the Algerian context. The advantages presented by this system are as follows:

- It does not need the knowledge of the marginal costs, especially in case of an emerging market as it is precisely the case for Algeria.
- Mastery of the quantities, thus of the allocated grants, in opposition to the tariffs of guaranteed purchase.
- Allocated efficiency: no undue income to the producers. The premium granted to them should compensate (theoretically) exactly the differential of the marginal costs with the conventional production.
- Dynamic efficiency: the technological advances are expressed by a drop in the costs of production, thus of the requested premium. The charge on the tariffs will be reduced.

12.1. Commission of regulation of electricity and gas (CREG)

The CREG (commission of regulation of electricity and gas) is commissioned (art. 113) to watch over the competitive and transparency functioning of the electricity market for the users and operator's interest. Its role is fundamental in the organisation and functioning of the electricity market, in general, and the renewable electricity, in particular. Article 128 of the law on electricity imposes on the operators to lodge with the CREG sale and purchase contracts of electricity. This provision permits to know exactly the quantity and nature of the electricity sold in the market. For the renewable electricity, it is thus possible to know its origin: thermal or PV solar, wind, biomass or geothermal. The granted premiums are according to the primary source of Mother Nature. Draft executive decree (PDE) relative to the costs of diversification of the electricity production takes its origin from the law relative to electricity. It states the nature of the costs of diversification relative to each technological option, fixes the methods of payment of the electricity produced from renewable sources, the conditions of evacuation of the produced energy as well as the mechanisms through which the state will ensure the penetration of the renewable energies according to a previously defined programme, in accordance with the energetic policy in the particular cases of an insufficient offer. As for all the calls for tenders, various reasons can make that one being insufficient compared to the requested quantity, or unfruitful and even subject to a justified cancellation. The legislator forecasted a mechanism likely to assure all the same the realisation of the programmed capacities and to achieve thus the goals with as much efficiency. It is about to solicit the contribution of the whole of the producers in the realisation of the forecasted capacity. It is fixed to them a share of production of renewable electricity, leaving them the possibility of making it produced by producers able to minimise the marginal costs. The draft decree fixed the costs of diversification. The producers perceive a premium fixed in advance for the production of their share of renewable electricity. The rates selected for a first period of application correspond to the differential in relation to the cost of the conventional electricity, which is variable according to the technology applied. It is also important to recall that the PDE obliges the manager of the transport network or the concession of distribution to sell the renewable electricity. The PDE recalls certain technical methods of connexion to the transport or distribution network, according to the cases, with a view to the evacuation of the energy.

12.2. National energy efficiency strategy

In 2003, the public authorities adopted the national energy efficiency policy, hence ordaining the implementation of the law of July 1999 relating to energy efficiency. The implementation mechanism for this strategy is constituted of four instruments defined within the framework of this law, namely the National Energy Efficiency Programme (PNME), the National Energy Efficiency Fund (FNME), the Inter-sector Energy Efficiency Committee (CIME) and the APRUE (the Algerian National Agency for the Promotion and Rationalisation of Energy Use), a mechanism to be reinforced by an incentive price policy and appropriate regulations.

12.3. APRUE – the national coordinator of the energy efficiency policy

Centre pin for the drawing up and implementation of the National Energy Efficiency Programme, the APRUE is the central element of the mechanism to implement this strategy. It is also responsible for the information, communication and management training missions of all the public players involved in energy efficiency and particularly the establishment of partnerships in order to draw up together transversal or sector action programmes, falling within the framework of the PNME and which may potentially benefit from the financial incentives of the FNME.

Approved by the Minister of Energy and Mines, the energy efficiency action plan proposed by the APRUE covered the period from 2004 to 2005. It falls within the framework of the implementation of the national energy efficiency strategy and has the essential role of encouraging and supporting the initiatives of the different players and to support them in their approaches. In this activities programme, APRUE'S main missions are set out in terms of sector objectives (national coordination, industry, residential, tertiary, transport, renewal energies, etc.) and in terms of related actions.

The period 2004–2005 was conceived as a pivotal period for the implementation of the national strategy and the energy efficiency mechanism which will see the emergence of an energy sector networks which I think will constitute the basis of the partnership necessary to the National Energy Efficiency Programme (PNME, 2005–2008) and the creation of energy efficiency equipment and services contracts. The objectives and the actions set out in this plan are mainly focused upon: the industrial sector, the residential sector, the road transport sector, the tertiary sector, the local communities and the renewable energies.

12.4. International cooperation activity in APRUE

The international cooperation is an important activity for the agency because of its contribution in terms of international expertise and know-how. For this purpose, APRUE has developed cooperation relations both within the bilateral and multilateral framework. The stake in MEDENER, the association of Mediterranean energy efficiency agencies, enables APRUE to keep up to date with the programme, projects and actions in the region, but also to make itself known to the financial backers and promote both the Algerian energy efficiency market and the energy policy at the international level. Within the bilateral framework, APRUE has developed projects particularly with France and Spain.

The cooperation with France is of an institutional nature. This cooperation was formed, in 2003, through an agreement between APRUE and its counterpart the ADEME (the French Environment and Energy Management Agency). With regard to the cooperation with Spain, it has approached two sectors: industry and road trans-

port. At the multilateral level, APRUE has benefited from donations from the European Commission, from the GEF (via the World Bank and the UNDP) within the framework of projects in several sectors. APRUE intends to develop the cooperation at the international level even more. Negotiations are underway with the Italian and Quebecois partner, the GTZ and UNESCO to develop, with their support, energy efficiency projects in partnership with all consumption sectors.

The actions planned for the years 2004 and 2005 had the objective of looking for and coordinating technical and financial international cooperation in order to support the national energy efficiency policy in Algeria, as well as to promote the Algerian energy efficiency market at the international level.

12.5. Energy outlook and the total programming

Besides the concern to better respond to the future energy demand, the energy outlook may lead to energy policy measure proposals which are best adapted to the objectives of the decision makers in charge of the Energy sector. Obviously, the energy outlook lives on data and indicators concerning the current energy system, but also information which may prefigure a future modification of the determining factors of supply or demand. The definition of the objectives and the drawing up of an energy efficiency action programme first of all requires a good vision of the economic situation, in general, and the energy situation in particular. APRUE will carry out an outlook exercise in order to establish the short term action programme on clearly highlighted stakes. It is important to maintain this activity and strengthen the national expertise on the subject. Furthermore, it is within this framework that the reference framework for the future energy efficiency programmes will be established.

The action plans for the outlook and programming for the years 2004 and 2005 particularly had the objectives of:

- Carrying out an energy supply demand outlook study 2010–2020 for the industry, transport, residential and tertiary sectors.
- Carrying out a study of the deposits and the potentials of the outlook study, broken down into sector actions and drawing up an energy efficiency priority objectives programme (PNME basic document).
- Developing expertise on the analysis and forecasting tools.

13. Clean development mechanism (CDM)

With the expansion of the Energy and Mining sector and the availability to the population and industry of energy products on a large scale, considerable efforts are needed to prevent the damaging of the environment and the quality of life in general.

In fact, the Energy and Mining sector attaches a great importance to issues related to the protection of the environment and public health. The integration of these concerns in the sector policy is based on the facet "energy and mines policy" of the governmental programme. This resulted in the implementation of measures essentially linked to the following objectives:

- The promotion and the development of the use of least polluting fossil fuels (natural gas, LPG, unleaded gasoline).
- The promotion of energy savings.
- The rehabilitation of polluted sites.
- The development of renewable energies.
- The development of the environmental management at the level of the Energy and Mining sector.

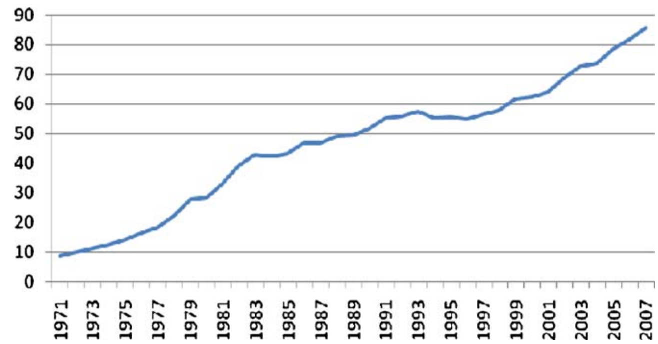


Fig. 5. Algerian CO_2 energy related emission in Mt (IEA souce).

The sector of energy reforms in the process of implementation assigns an important place to the environment; special provisions are thus introduced by the new laws on Mining and Electricity production. The carrying out of impact studies on environment; the implementation of environment management plans and the auditing on the complexes with respect to environment are made obligatory by the sector and also under its responsibility.

The integration of the environment protection and the sustainable development within the formulation of the policy, planning and management is imperative to the sector given the necessity of protecting natural habitats, public health and also the commitment of the country relative to the international legal instruments and to different agreements and conventions entered into the country.

The main emitters of greenhouse gases (GHG) are fuel combustion in the energy sector, in industry, and in the transport sector. Other important contributors are agriculture, small combustion, non-combustion emissions in industry and waste. The structure of the Algerian primary energy supply is very favourable with respect to GHG emissions. GHG emissions in Algeria (Fig. 5) amount to about 84 million of tons [19] (fourth position in the Arab world).

Comparing with other countries, Algeria's contribution to global climate change is very small and up to now, Algeria meets all the requirements of signed international conventions in the field of atmospheric pollution. Algeria is also involved in the carbon capture and storage (CCS) technology, with one of the very few functioning projects in the world.

The gas from the In Salah field has a high CO_2 concentration, which needs to be decreased to reach pipeline specifications. After removal, instead of being released into the atmosphere, the CO_2 is re-injected into an aquifer that is part of the same geological formation as the gas field. Today, the In Salah gas plant is in full operation. Produced CO_2 from the natural gas stream is removed in the desert processing plant and is being sequestered into underground storage. Close monitoring for performance is being made on this large operation by Sonatrach, BP and Statoil [20]. These same firms are also developing the In Amenas gas condensate field which lies close to the Libyan border.

14. African Energy Commission (Afrec)

As recommended by its convention, the Afrec has prepared a series of draft energy programmes, including oil, gas, electricity, renewable energies, coal, nuclear power, training and strengthening of capacities and the information system.

14.1. Progress of the Afrec Programme on the sustainable development of electricity

Below is a summary of the Afrec Programme on the sustainable development of electricity [21,22].

Resources

- Vast hydro-energy programmes
- Micro and small hydro-energy projects
- Solar power resources (photovoltaic and thermal)
- Wind energy conversion systems
- Geothermal electric production
- Energy efficiency

Means

- Afrec's Programme for the sustainable development of energy
- Sponsoring of continental strategies and policies (renewable energy and sustainable development managers)
- Mobilising the African organisations dealing with energy
- Mobilising the African regulatory and legislative instructions
- Popularising energy management
- Creating the African Renewable Energies company (ARES)
- Boosting the regional power pools (RPPs)
- Popularising energy management

Goals

The popular companies will contribute to the following:

- For a sustainable Africa

  - Encouraging the use of the renewable energies throughout the continent, through the appropriate technology, scientific excellence, social responsibility and continental communication.

- Establishing African communities

  - Bringing together the industries, individuals and institutions to support the renewable energy technologies, through communication, cooperation, support and exchanges.

- Development support

  - Applying practical projects, transferring technology, education, training and supporting issues of African energy development.
  - Supporting the renewable energy technology sciences: stimulating and encouraging fundamental and applied research into the renewable energy technologies.

- Contributing to growth

  - Ensuring individual and community growth by supporting the private company and providing training in the domain of renewable energies.

- Information and communication

  - Quick access to information through communication and exchange platforms designed on the basis of modern technologies.

- Stakeholders

  - Afrec
  - Continental energy organisations
  - Local communities
  - Futuristic non-governmental organisations (NGOs)
  - National and local governments
  - Specialised United Nations institutions
  - International organisations concerned
  - International bilateral donators affiliated to the countries

- Global partners

  - The International Solar Energy Society (ISES)
  - The World Bank and associated partner organisations
  - Development Banks
  - Specialised United Nations (UN) institutions
  - the International Energy Agency (IEA)
  - The European Union (EU)
  - the Eurec Agency
  - The World Wind Energy Association (WWEA)
  - Governments
  - Industrial and services' organisations
  - Non-governmental organisations
  - Research institutes
  - Universities
  - Public services

- Functions and activities

  - The continental people's sustainable energy society will include a large range of services, activities, networks and support mechanisms. A group of custom-made professional services will be reinforced by a continental and global interaction, quick access to information, concerted projects and a community of individuals sharing the same opinions. Affecting all domains of energy supply and sustainability, membership to such a society may contribute to sustainable development, to a healthier environment, to scientific responsibility and to economic prosperity.

- It may

  - Promote extended short and long term use of renewable energies.
  - Organise popular scientific and awareness conferences.
  - Publish reviews, books, information on-line and policy statements.
  - Sponsor round tables and organise debate platforms.
  - Distribute brochures and publications on renewable energies, and organise the regional and continental networks of the renewable energy societies.

15. Promotion and trend in the development of renewable energy sources in Algeria

The North Africa is perfectly placed to play a leading role in the lucrative future solar power industry, says a report released on October 2005 by Science and Development Network (SciDevNet). The report says that in 20 years, solar power could provide the same amount of electricity as 72 coal-fired power stations. This is enough to supply 100 million people, or the combined populations of Algeria, Morocco, Tunisia and Libya. By 2040, solar thermal power plants could supply 5% of global electricity demand. Algeria is in urgent need of an adequate energy infrastructure so that it can achieve higher levels of economic development. This would allow all of its inhabitants access to a quality energy supply, irrespective of their place of residence. Crucial objectives are targeted at substantially increasing and enhancing the contribution of renewable energies and favouring energy self-sufficiency.

The objectives established by NEAL are focused on raising renewable energy production to 1400 MW in 2030 and 7500 MW at the beginning of 2050. The electrical power will be obtained from solar power plants, which are exclusively solar, or from hybrid solar plants, which also use other forms of renewable or conventional energy, preferably natural gas (Table 9).

The Algerian Government has been promoting the use of renewable energy by means of a series of laws and official programmes already mentioned (Table 10) [23].

Table 9
Total programme plans and objectives by NEAL.

Needs	Local (MW)	Export (MW)	Total (MW)
2015	500	75	575
2000	1000	400	1400
2050	1500	6000	7500

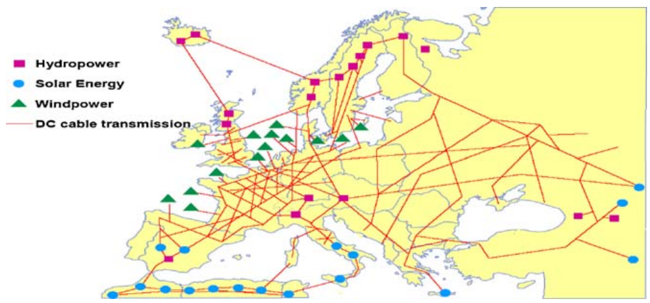


Fig. 6. Interconnection North Africa–Europe through the Mediterranean Sea.

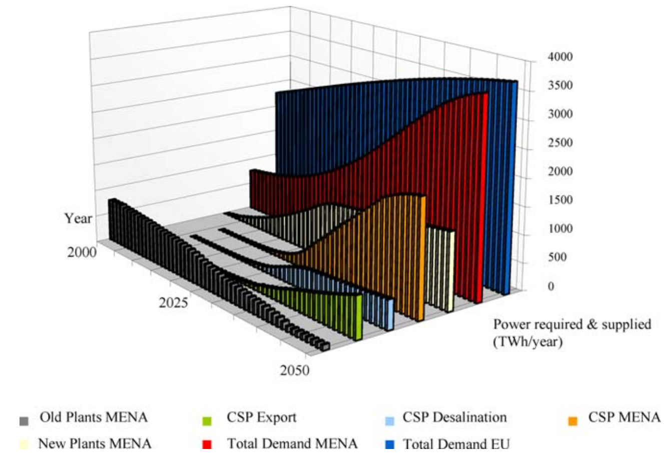


Fig. 7. Interconnections MENA-Europe, power required & supplied for different applications.

NEAL has solicited several sources of funding and supporting its projects. On the one hand, the projected objectives is included within a solicited actions supported and financed by the world bank, IEA and the European bank of investment, whereas on the other, it also receives funds from the Algerian Government (Ministry of Energy and Mines).

By 2030, Algeria aims at generating 20% of its electricity from renewable sources, 70% of which from CSP, 20% from PV and 10% from wind. The country's strategy to develop renewable energy sources and implement a low carbon economy fully supports its efforts to reduce vulnerability to oil prices and hydrocarbon exports. Algeria intends to become a leading nation in the renewable sector, including in manufacturing components, thanks to abundant domestic resources and targeted policies.

Algeria could one day be exporting solar energy to markets in Europe, as they will soon be connected to European energy networks. In fact, the Algerian Energy Company (AEC), Sonatrach and Sonelgaz in partnership with foreign companies (Spain and Germany) will realise, by 2010, a 2000 MW project of which a share of the production will be exported to Europe (4% of the projected power or 75 MW will be produced by a 400 MW concentrated solar-gas hybrid station in Hassi R'mel) [23]. Plans are underway for two undersea cables with capacity of 1.2 GW each from Algeria to Spain and Italy as seen in Fig. 6 which represent the concept of a MENA-Europe Link using HVDC power transmission.

In view of the increasing energy intensity, the Government has emphasized energy efficiency and renewable energy options. The National Energy Efficiency Fund of Algeria (FNME) was created in 2000 (Decree No. 2000-116), with the objective of financing energy efficiency investments as well as the budget of the National Energy Efficiency Agency (APRUE) and the projects it manages under the National Energy Efficiency Program (PNME), FNME's annual budget is estimated at DA 500 million (Euro 57 million). The resources of the funds include taxes on natural gas (DA 0.00015/btu) and electricity (DA 0.02/kWh), and an initial government contribution of DA 100 million (Euro 1.15 million). Additional resources may include taxes on energy intensive equipments, penalties, loan reimbursements, and government or other contributions [10].

15.1. Total MENA-Europe HVDC interconnections (by DLR)

Algeria is planning the realisation of the projects of cables towards Europe. The concept of a MENA-Europe Link using High Voltage Direct Current power (required and to be supplied for different applications) transmission technology is summarised as follow (see also Fig. 7):

- Capacity 20 × 5 GW (∼7% of total capacity)
- Operation 7000 h/y (∼Nuclear Plant Performance)
- Electricity 700 TWh/y (∼17% of total production)
- Investment 395 Billion € (∼4000 €/kW)
- Electricity cost 5–6 cent/kWh (∼coal plant with CO_2 sequestration)
- Land area 50 km × 50 km (∼0.025% of the Sahara for CSP) + 3600 km × 1 km (∼0.035% of Europe for HVDC)

16. Other forms of renewable resources, solar hydrogen

The solar-hydrogen energy system for Algeria would could extend the availability of fossil fuels resources, reduce pollution, and establish a permanent energy system. It could do so by solar

Table 10
A total list of power production with renewable energy sources up to 2015.

Project and place	Capacity (MW)	Bill-book	Cost ($\$ \times 10^6$)	Observation
SPP1, Hassi R'mel	150	2008–2010	160	Hybrid, solar power plant-gas
SPP2, Naama	400	2010–2013	286	Solar power plant
SPP3, Megha	400	2012–2014	286 + 120	Solar power plant + unsalted process
SPP4, Hassi R'mel	400	2012	286	Hybrid, solar power plant-gas
Total	1350		1138	
WPP1, Adrar	10	2010–2012	23	Wind power plant
WPP1, Tindouf	6	2012–2015	13	Wind power plant
WPP2, Tindouf	10	2012–2015	23	Wind power plant
WPP3, Timimoun	10	2012–2015	23	Wind power plant
WPP4, Bechar	10	2015	23	Wind power plant
Total	36		82	



Fig. 8. Mediterranean electricity loop.

production of hydrogen and then utilising hydrogen as an energy carrier as well as exporting it to Europe. This would provide Algeria with a clean permanent energy system, and would enable it to maintain and improve its overall GNP, as well as improving its quality life. Algeria and the International Energy Agency agreed on technological cooperation in developing solar-hydrogen economy [24,25]. The Algerian Hydrogen Association (2AH) has been created in June 2005 during the hydrogen conference held in Algiers.

Initial work has already began in the areas of utilising solar energy in producing hydrogen (CDER) for fuel cell but have not yet resulted in power generation and are rather in primary stages as compared with the work on solar and wind energy sources.

At the moment natural gas steam reforming is a likely initial source of hydrogen, due mainly to being a highly established process and having both natural gas distribution infrastructure and large scale hydrogen production facilities already in place.

17. Conclusion

Algeria is endowed with large reserves of energy sources, mainly hydrocarbons and solar energy. Regarding the completed assessment work done by the DLR, it appears that there is a considerable potential for the utilisation of renewable energy sources especially with respect to solar and wind power. However the level of development of such energy sources is rather primary, but efforts should increase because of the ever growing concern about the environment friendly sources of energy. It is now important in educating the public as well as introducing special energy legislation to increase the usage of this clean form of energy whether in private or public sectors and show the importance of energy efficiency and conservation. Renewable energies are now one of the major elements of Algeria's energy policy. The various future projects are all factors that will undoubtedly give Algeria an important role in the implementation of renewable energy technology in North Africa, the capacity for providing sufficient energy for the needs of the population, and the possibility of even exporting such projects to neighbouring countries as shown in Fig. 8 which represents the interconnection between north Africa, including Algeria, and Europe.

The high level of insolation in Algeria, the presence of the Solar project of Hassi R'mel, an important source of experience in solar energy techniques by NEAL, as well as various projects financed and promoted by national and private industry are all factors that will undoubtedly give Algeria an important role in the implementation of renewable energy technology in MENA region, the capacity for providing sufficient energy for the needs of the population, and the possibility of even exporting such projects to other countries in Europe.

The population distribution in Algeria also shows that there is a great potential market for renewable energies, among which solar energy should be highlighted because of its homogeneous presence throughout the entire region.

References

[1] Muneer T, Asif M, Munawwar S. Sustainable production of solar electricity with particular reference to the Indian economy. Renew Sustain Energy Rev 2005;9:444–73.
[2] CDER Algeria. "Experience, potential and algerian PV market" applied renewable energies workshop (WIERA 2009). Bejaia, Algeria; 17–18 November 2009.
[3] International Executive Conference on Expanding the Market for Concentrating Solar Power. Renewable energy opportunities in Algeria. CA: Palm Springs; 2003. October 23–24.
[4] African Economic Outlook 2007–2008. www.oecd.org/dev/publications/africanoutlook.
[5] Energy & Mines Book 2004 and 2007. www.mem-algeria.org.
[6] Energy & Mines Book 2007. www.mem-algeria.org.
[7] Cherigui A, et al. Solar hydrogen energy: the European–Maghreb connection. A new way of excellence for sustainable energy development. Int J Hydrogen Energy 2009;34(11):4934–40.
[8] L'Actual No. 81. Les Nouvelles Revues Algérienne; July 2007. www.actual-dz.com.
[9] Energie & Mines. Review of the energy and mining sector. No. 06; November 2007.
[10] World Bank Group, ESMAP. Tapping a hidden resource – energy efficiency in the Middle East and North Africa. Report No. 48329-MNA. Washington, DC: World Bank Group; 2009.
[11] NEAL Algeria. www.neal-dz.net/activite.html.
[12] Energie & Mines. Review of the energy and mining sector. No. 03; November 2004.
[13] CDER Algeria. http://www.cder.dz.
[14] Energie & Mines. Review of the energy and mining sector. No. 02; April 2004.
[15] MEM 2005. http://www.mem-algeria.org/fr/enr/carte_vents.htm.
[16] MEM 2005. www.mem-algeria.org/fr/enr/pot.htm#hydrélectricité.
[17] Energie & Mines. Review of the energy and mining sector. No. 06; November 2006.
[18] Energie & Mines. Review of the energy and mining sector. No. 08; November 2008.
[19] IEA Press; June 2008.
[20] Driscoll J, Benyoub S, Riddiford F. International conference on integrated sustainable energy resources in arid regions, sub: environment 2007."CO_2 Sequestration in the In Salah Gas Project". Abu-Dhabi, UAE; 2007.
[21] AFREC Algeria. http://afrec.mem-algeria.org.
[22] African Economic Outlook 2005–2006. www.oecd.org/dev/publications/africanoutlook.
[23] Hasni T. Former president of NEAL "Développement des Energies Renouvelables en Algérie". National conference on renewable energies and sustainable development. Laghouat, Algeria; 2006.
[24] IEA Press. Algeria joins IEA Solarpaces. Paris: IEA/Press (03) 01; January 13, 2003.
[25] IEA Press; June 2005.